Australian Government
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DSTO

Reformatting Meteorological Data for use in the Hazard Prediction and Assessment Capability

Alexander Hill, Peter Sanders
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CBRN Defence Centre
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ABSTRACT

The Hazard Prediction and Assessment Capability (HPAC) is a hazard modelling tool that predicts the effects of the release of toxic materials to the atmosphere. Detailed meteorological data is required to obtain reliable modelling results, including surface observations, upper-air profiles and gridded forecast data. HPAC is a US developed model and cannot interpret locally available meteorological data. This report describes the DSTO-built computer program AWSMSTR which retrieves the relevant data from a remote server and reformats it for use in HPAC.

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Executive Summary

The Hazard Prediction and Assessment Capability (HPAC) is used by the Incident Response Regiment (IRR) to predict the effects of the release of toxic materials to the atmosphere. The reliability of these predictions is heavily reliant on the input data, especially the meteorological data, which is used to build the wind field and turbulence structure that drives the dispersion calculation. Depending on the scenario being modelled this meteorological data may be in the form of surface and upper-air observations or forecast data from mesoscale model runs.

In Australia, this meteorological data is produced by the Bureau of Meteorology (BoM). HPAC was developed in the United States and so is not compatible with Australian meteorological data formats. This report describes work undertaken by DSTO to construct a computer program (called AWSMSTR) that automatically downloads requested data and reformats it for use in HPAC. Included in the report are descriptions of both the BoM and HPAC formats for various data types and the formulae used in the conversions. Justification for the assumptions made when converting gridded forecast data and an explanation of the probable errors involved are also provided.

The AWSMSTR software enables Australian HPAC users in both the defence and civil communities to access the most up-to-date meteorological information available. The software has been designed to ensure that the reformatting of new data formats is as simple as possible and is available to licensed HPAC users upon request to the authors.

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1. Introduction

The suite of modelling tools known as HPAC (Hazard Prediction and Assessment Capability) is used by the Incident Response Regiment (IRR) to predict the hazards that result from releases of Chemical, Biological, Radiological and Nuclear (CBRN) materials into the atmosphere. HPAC, developed in the US by the Defense Threat Reduction Agency (DTRA) calculates the initial cloud of material resulting from the use of Weapons of Mass Destruction and the resulting dispersion. This information is provided to the user of the software in the form of plots of concentrations, doses, deposited material, etc.

The dispersion process is heavily reliant on the meteorological conditions present. To be used effectively, HPAC requires not only surface and upper-air observations, but also detailed gridded forecast data. This data is readily available in the United States, but has not been available in Australia in a format that can be interpreted by HPAC. The Bureau of Meteorology (BoM) collects large amounts of observational data from across the country and uses Numerical Weather Prediction (NWP) models to produce detailed forecasts.

This report explains the process undertaken by DSTO to create specialised programs that automatically download both observational and forecast data from the BoM and process it into formats that HPAC understands. It also provides some detail on the formats themselves, including the HPAC internal formats and how they relate to the standards used by the BoM.

2. Observational Data Formatting

2.1 Surface Observations

HPAC can read surface observations from weather files in its native format, known as "`.sfc`", and also has the ability to import international METAR (Meteorological Aerodrome Report) standard format files.

Surface observations from the BoM are in "`.axf`" format, its standard for surface observations (axf stands for AIFS (Australian Integrated Forecast System) Exchange Format). The `.axf` format is used to record data from various observational stations, such as automatic reporting stations, manned stations and harbour buoys, etc. The data from these stations are recorded in different types of `.axf` format, depending on the end-user and the nature of the data. The two main types of `.axf` format that were considered by DSTO for use with HPAC are "[SURFACE]" and "[metar2Data]".

2.1.1 BoM format

During the visit to the BoM in mid 2003, DSTO was provided with an example of the [SURFACE] `.axf` type for recording surface observations. Due to the similarity of this format to the native HPAC surface observation format, `.sfc`, the reprocessing of [SURFACE] files was initially considered to be the best option.

However, most HPAC projects will only require a small proportion of the total available surface observations over Australia. It was eventually decided that the METAR format would be preferable for surface observations as HPAC allows an efficient filtering of irrelevant observations. There is some loss in accuracy in the importing process due to rounding errors, as METAR can only deal with integral values of the temperature and dewpoint. To minimise reformatting, the BoM supplied the surface observations in another `.axf` type, called [metar2Data], details of which are presented in Table 1.

Table 1: Detail of [metar2Data] aviation .axf type format

BoM Variables	ID_num	ID_name	Date	Time	Lat
Variable Description	5 Digit Station Identifier	4 Letter Station Identifier	Date (YYYYMMDD)	Time (hhmm)	Latitude (deg N)
Example Values	95304	YBWX	20031008	0448	-20.88
BoM Variables	Lon	Wdir	Wspd	T_DB	DP
Variable Description	Longitude (deg E)	Wind Direction (deg)	Wind Speed (knots)	Temperature Dry Bulb ($^{\circ}$C)	Dewpoint Temp ($^{\circ}$C)
Example Values	115.41	050	15	30.7	11.7
BoM Variables	QNH	RF9am	RF10m	Vis	Avis
Variable Description	QNH Pressure (hPa)	Precipitation Since 9 am Local (mm)	Precipitation - Last 10 mins (mm)	Not used by HPAC	Not Used by HPAC
Example Values	1013.5	0.0	0.0	-9999	-9999
BoM Variables	Gust	Wx1Int	Wx1Dsc	Wx1Wx1	Wx1Wx2
Variable Description	Max Wind Gust Since 9am (kts)	Not Used by HPAC	Not Used by HPAC	Not Used by HPAC	Not Used by HPAC
Example Values	20	-9999	-9999	-9999	-9999
BoM Variables	Wx1Wx3	Wx2Int	Wx2Dsc	Wx2Wx1	Wx2Wx2
Variable Description	Not Used by HPAC	Not Used by HPAC	Not Used by HPAC	Not Used by HPAC	Not Used by HPAC
Example Values	-9999	-9999	-9999	-9999	-9999
BoM Variables	Wx2Wx3	Cld1Amt	Cld1Typ	Cld1Base	Cld2Amt
Variable Description	Not Used by HPAC	Not Used by HPAC	Not Used by HPAC	Not Used by HPAC	Not Used by HPAC
Example Values	-9999	-9999	-9999	-9999	-9999
BoM Variables	Cld2Typ	Cld2Base	Cld3Amt	Cld3Typ	Cld3Base
Variable Description	Not Used by HPAC	Not Used by HPAC	Not Used by HPAC	Not Used by HPAC	Not Used by HPAC
Example Values	-9999	-9999	-9999	-9999	-9999

BoM Variables	Cld4Amt	Cld4Typ	Cld4Base	Ceil1Amt	Ceil1Base
Variable Description	Not Used by HPAC	Not Used by HPAC	Not Used by HPAC	Not Used by HPAC	Not Used by HPAC
Example Values	-9999	-9999	-9999	-9999	-9999
BoM Variables	Ceil2Amt	Ceil2Base	Ceil3Amt	Ceil3Base	
Variable Description	Not Used by HPAC	Not Used by HPAC	Not Used by HPAC	Not Used by HPAC	
Example Values	-9999	-9999	-9999	-9999	

Notes: *1) If data is not available, then the value –9999 is used as a flag*
2) Each observation takes up a single "line" in the observation file (comma separated) – these lines when concatenated form the observation file (Appendix A)
3) Data not imported by HPAC includes precipitation, visibility and other more general cloud information and remarks

The [metar2Data] type contains a lot of variables whose values are not used in HPAC, creating an inefficiency that would normally be avoided. However, due to the very small file sizes and the effort that would be required by the BoM to deliver a non-standard format, this has not arisen as an issue.

Some surface weather stations report every 15 minutes, while others have a reporting interval of up to three hours. This means that when selecting any given set of observation files, the latest observation from all stations within the modelling domain may not be included. A very simple way to ensure that up to date observations are used is to select a set of weather files spanning at least three hours before until three hours after the boundaries of the model's temporal domain when importing surface observations.

2.1.2 HPAC Format

The HPAC User's Guide [1] contains a detailed description of the HPAC native `.sfc` format. It also contains some information on the standard METAR format, a more rigorous definition of which can be found in the meteorology text [2] by Whiteman. There are many variables in the standard METAR format that are not utilised by HPAC, so the final format used for the surface observations is not strictly a standard METAR format. Table 2 below gives a brief description of the variables that are included in the HPAC METAR files. An example output file can be found in Appendix A.

The data is saved in an ASCII text file with the extension "`.sao`" in space delimited format, with each observation beginning on a new line, as required by HPAC. The downloaded files vary in size as the automatic weather stations report at a range of frequencies, with the largest files being around 125 kb. The reformatting process

removes a lot of the information, so the METAR files that are output from the program are typically reduced in size by a factor of approximately seven.

Table 2: METAR format used in HPAC

Variable Form	Obs_Type	LLLL	DDhhmmZ	DDDssKT	////	DB/DP	Qpppp
Variable Description	Label indicating Meteorological Aerodrome Report	4 Letter identifier for station	Date & Time, with Z appended indicating UTC	Wind direction & speed, with KT indicating knots	Slashes indicate missing or unused data	Dry Bulb Temp and Dewpoint separated by /	Pressure (hPa) (Q indicates QNH)
Example Value	METAR	YHLC	161230Z	15009KT	////	24/20	Q1012

Notes: 1) The 4 central slashes - //// - indicate that there are no comments for this report. HPAC ignores these comments if they exist.

2) If temperature or dewpoint are less than zero, then they are prefixed with the letter M to indicate negative temperatures (i.e. –12 is M12).

3) If data is not available for any variable, it is replaced by ////, except in the case of pressure, which becomes Q////.

4) Data not imported by HPAC includes precipitation, visibility and other more general cloud information and remarks.

Each observation records only the four-letter ID code as a means of identifying the station (also known as the International Civilian Aviation Organisation (ICAO) identifier), but HPAC also requires the location of this station to make use of the data. This is done by a simple process of using the four-letter ID code as a key to a lookup table, and HPAC stores this information in the file `wmo.stn`, which is stored in the `C:\HPAC4\client\runs\data\wxstn` and `C:\HPAC4\client\data\wxstn` directories. The format of this look-up table is explained in section 7.6.2 of the User's Guide [1]. The BoM provided DSTO with a list of all stations and their corresponding ID codes, which was used to update the `wmo.stn` file. Note that the upper air format uses a similar system, but identifies stations via their 5 digit ID's.

Importing the METAR surface observation files into HPAC then proceeds via the Weather Wizard, *Import Other Files* > *Open* > *Scattered* > *Select Max Stations* > *OK*.

2.2 Upper Air Observations

The upper-air observations supplied by the BoM are in the standard RAOBS (Rawinsonde Observation) format, which HPAC can import easily. The RAOBS format is quite complicated, but an overview can be found in Appendix C of the User's Guide [1]. The Federal Meteorological Handbook [3] contains much more detailed information on the RAOBS format and is available on the Internet. The data are written in ASCII format, and so can be viewed by most text editors. The only modification that HPAC requires is that the file extension be changed from `.txt` to `.wmo`. The process to load the files into HPAC is the same as for the surface METARs,

and users will normally import both upper air and surface observations simultaneously by selecting files with extensions `.sao` and `.wmo`. HPAC will extract all observations from within its modelling domain and write them to an `.sfc` and `.prf` file, where `.prf` is the native HPAC format for upper air observations (see below).

HPAC can process the different parts of the RAOBS coded observation, TTAA (mandatory levels), TTBB (significant levels with respect to temperature/humidity), PPBB (significant levels with respect to wind) and the three levels that provide 100 hPa to 10 hPa data, TTCC, TTDD and PPDD. These files are very small, usually around 1-30 kb, so they are processed very quickly.

3. Forecast Data Reformatting

3.1 NetCDF Format

The BoM produce NWP gridded forecasts using the Mesoscale Limited Area Prediction System (MesoLAPS) every 12 hours. This data is written in NetCDF (Network Common Data Format) format, commonly used for scientific data. Unfortunately HPAC cannot interpret NetCDF data, so a major part of the project has been to write a conversion program that translates from NetCDF to HPAC's format for gridded data. The MesoLAPS NetCDF files supplied by the Bureau of Meteorology are stored in a binary form and contain the variables shown below in Table 3.

Table 3: Current NetCDF format variable definitions

Variable Name	Description	Units	Varies with	Used in reformatting
lon	Longitudes	degrees E	1-D Array	Yes
lat	Latitudes	degrees N	1-D Array	Yes
lvl	Vertical Levels		1-D Array	Yes
time	Days Since Forecast	time	scalar	No
seg_type	Header Information		char_size, time	No
tm_step_size	Time Step Size	seconds	scalar	No
base_date	Base Date of Data Segment	date	string	No
base_time	Base Time of Data Segment	time	string	No
valid_date	Valid Date of Data Segment	date	string	Yes
valid_time	Valid Time of Data Segment	time	string	Yes
air_temp	Air Temperature	K	time, lvl, lat, lon	Yes
zonal_wnd	U Direction (W-E) Winds	m/s	time, lvl, lat, lon	Yes
merid_wnd	V Direction (N-S) Winds	m/s	time, lvl, lat, lon	Yes
omega	W Direction (vertical) Winds	Pa/s	time, lvl, lat, lon	Yes
mix_rto	Humidity Ratio	kg/kg	time, lvl, lat, lon	Yes
sfc_pres	Surface Pressure	Pa	time, lat, lon	Yes

geop_ht	Geopotential Height	m	time, lvl, lat, lon	Yes
mslp	Mean Sea Level Pressure	hPa	time, lat, lon	No
topog	Terrain Elevation	m	time, lat, lon	Yes
abl_ht	Atmospheric Boundary-Layer Height	m	time, lat, lon	Yes
sfc_ttl_heat_flx	Total Surface Heat Flux	W/m^2	time, lat, lon	Yes

Note that initially DSTO received just the raw NetCDF files with all available variables included, as produced by the BoM for other purposes. However, some variables that were critical to DSTO were not normally used by the BoM and hence were included only as dummy values. BoM were then able to provide a smaller, custom-built set of files in the NetCDF format for use with HPAC. The NetCDF files are in a binary format, so a NetCDF viewer is required to access the data and labels - several of these are available on the Internet [4].

The resolution of the data is reasonable, with a 5 km grid size for the Sydney and Melbourne regions, and 12 km gridded data available for all other major centres. To obtain reliable hazard estimates when modelling over small spatial domains requires higher resolution data, but this is not currently available in Australia.

3.2 Gridded Weather Formats Accepted by HPAC

3.2.1 HASCAL Gridded Format

HPAC has its own native gridded weather format, known as the HASCAL (or HPAC) gridded format. The HASCAL grid has no flexibility in the types of data that can be included; it demands that the only four inputs are the U (east-west) and V (north-south) components of wind velocity, temperature and relative humidity. The other option for inputting gridded forecast data into HPAC is the MEDOC format (described in detail below), which allows for many different combinations of variables, and so was preferred over the HASCAL format. More detail on the HASCAL format can be found in the User's Guide [1] and the SCIPUFF Technical Document [5].

3.2.2 Upper Air Profile Format

Another option that was explored was to use the internal HPAC format for upper air profiles (`.prf` files) to write the grid. This was examined because the NetCDF format is written in terms of constant pressure levels, whilst MEDOC demands constant height levels. The `.prf` format also uses pressure levels, so this would save considerable programming and reduce errors due to interpolating data from pressure levels to height levels. Conversely, HPAC ingests gridded data much more efficiently than profile data, and run times for profiles would be significantly higher when compared with the corresponding MEDOC files. Since model run times are likely to be critical when using HPAC operationally it was decided that the `.prf` format was not appropriate.

3.2.3 MEDOC Format

The MEDOC format was developed for use by the French Electricity Board in pollutant dispersal programs. The developers of HPAC, the DTRA (then the Defense Nuclear Agency) were involved with this work, hence the connection between MEDOC and HPAC. MEDOC was not specifically designed for HPAC, so there are aspects of the format that are ignored, such as visibility information and precipitation rates. The HPAC Users Guide [1] and the SCIPUFF Technical Document [5] contain details of the MEDOC format, but are brief and at times contradictory, so some aspects will be elaborated upon here.

Table 4: The MEDOC format description

8 letter string, F's for formatted, B's for binary					
FFFFFFFF					
Name of the code used (NOT used by HPAC)					
TRNSGRIB					
Day	**Month**	**Year**	**Hour**	**Minute**	**Second**
12	3	1	12	0	0
Day	**Month**	**Year**	**Hour**	**Minute**	**Second**
12	3	1	12	0	0
# of Grid Points – x	**# of Grid Points - y**	**# of Grid Points - z**	**Number Special Points (NOT Used by HPAC)**	**Number 3D variables**	**Number 2D variables**
4	3	15	0	6	1
Dummy variable	**Dummy variable**	**Dummy variable**	**Dummy variable**	**Dummy variable**	**Dummy variable**
0	0	0	0	0	0
Dummy variable	**Dummy variable**	**Dummy variable**			
0	0	0			
Terrain following grid levels					
145.7986	359.5139	576.3943	798.9402	1025.5447	1494.7405
1985.2294	3041.166	5611.5967	7230.8535	9199.6895	10379.626
			Grid Spacing (m or deg)	**Grid Spacing (m or deg)**	**Grid Origin - x (kms)**
11766.4102	13523.1162	16047.8145	1	1	-999999
Grid Origin - y (kms)	**Grid Origin (lat)**	**Grid Origin (lon)**	**Dummy variable**	**Dummy variable**	**Dummy variable**
-999999	39.43	-113.7	0	0	0

Time of this data set

Time of initial calculation (NOT used by HPAC)

Set special points to zero

Hence number of grid points = 4 x 3 x 15 = 180

Set dummy variables to zero, ignored by HPAC

The height above sea level of the southwest corner of the grid is defined for each of the 15 vertical levels

Dummy variable	Vertical Domain height (m)
0	0

If Vertical domain height not specified (zero value), then max vertical height for meteorology is assumed to be HPAC project domain height

Name of 3D variables

U	V	W	T	H	PHI

Units of 3D variables

M/S	M/S	M/S	KELVIN	GM/GM	METERS

Names of 2D variables	Units of 2D variables
TOPO	METERS

Other possible variables include wind variance, heat flux and boundary layer height

List of data for first 3D variable, read from left to right (W to E), then up (S to N), then vertically

4.7194	4.0831	3.123	3.1447	5.181	3.8197
2.6974	3.1469	4.77	3.6373	3.561	4.6838
...	...				...
...	...				...
...	...				...
...	...	...	...	...	...
8.6923	10.4461	12.1306	13.4434	8.3102	9.6627
11.1441	12.349	8.9767	9.9146	10.9582	11.8431

U winds data (west is positive), 180 points, in m/s

List of data for second 3D variable, read from left to right (W to E), then up (S to N), then vertically

-2.9386	-1.6359	-0.0655	0.8006	-1.9595	-0.1594
0.6897	0.3719	-1.7097	0.3943	0.8394	-0.1985
...	...				...
...	...				...
...	...				...
...	...	...	...	...	...
-2.987	-3.2447	-3.7645	-4.1708	-4.6217	-4.9667

V winds data (north is positive), 180 points, in m/s

List of data for third 3D variable, read from left to right (W to E), then up (S to N), then vertically

0	0	0	0	0	0
0	0	0	0	0	0
...	...				...
...	...				...
...	...			...	...
...	...	...	...	...	...
0	0	0	0	0	0

W winds data (vertical winds), 180 points, in m/s

List of data for fourth 3D variable, read from left to right (W to E), then up (S to N), then vertically

286.3005	286.2977	285.9251	285.467	285.0277	285.5887
285.793	285.7087	284.5406	285.2825	285.6671	285.6915
...	...	...			...
...	...	...			...
...	...	...			...
...	...	...	...	...	...
412.1619	413.1445	411.0605	411.671	412.4677	413.499

Potential temperature (K) at each point

List of data for fifth 3D variable, read from left to right (W to E), then up (S to N), then vertically

0.0023	0.0026	0.0027	0.0031	0.0025	0.0025
0.0024	0.0028	0.0024	0.0023	0.0024	0.0026
...	...	...			...

Humidity ratio (gram/gram) at each point

...	...	...		...	...
...	...	...		...	...
...	...	...	...	...	...
0	0	0	0	0	0
List of data for sixth and final 3D variable, read from left to right (W to E), then up (S to N), then vertically					
154.1142	145.0238	132.6476	120.1434	160.2519	149.8387
135.0083	120.0095	159.3593	147.2832	131.7708	116.0533
...	...	PHI – geopotential height (m) – no longer used by HPAC			...
...	...				...
...	...				...
16005.5049	16002.068	16003.5996	15997.9414	15992.5869	15987.5498
List of data for single 2D variable, read from left to right (W to E), then up (S to N)					
2078.2341	2103.6545	2229.3638	2272.1587	1875.5222	1904.1626
2142.7893	2338.1506	1740.0813	1796.8811	2076.2375	2346.7925
Process then repeats for each time-step included in the MEDOC file.					

The MEDOC file has three main sections - the header section, which contains information about the grid and the variables that are included in the file, the 3-D variables section, which includes wind, temperature, etc. and their values, and the 2-D variables section, which describes topography and heat flux. Table 4 contains a basic description of a MEDOC file with example values (shaded) from a small 4 x 3 grid with 15 vertical levels at one-degree spacings and notes on how HPAC interprets the MEDOC data.

3.3 Interpolation Issues

Unfortunately, the MesoLAPS and MEDOC grids that form the basis of the forecast data are quite different. The MesoLAPS files record all data on the basis of fixed sigma levels, which correspond to constant fractions of the surface pressure. This type of structure is very common in meteorological modelling, both in Australia and overseas. Unfortunately the MEDOC data is recorded at levels of fixed vertical height relative to the ground (so terrain is incorporated into the file without the need to specify a terrain file separately). This incompatibility necessitates the interpolation of all three-dimensional data to constant height levels (defined by the height of the southwest corner of the domain) from constant sigma levels (fraction of the surface pressure). Figure 1 shows a cross-sectional view of the situation, with the blue horizontal lines representing lines of constant atmospheric pressure. The red contours represent the levels on the NetCDF files, which are a fraction of the pressure at the surface, and the black dotted line shows the MEDOC level closest to the surface. Due to the non-linear decrease in pressure with linear increase in height, we expect the vertical difference between the MEDOC and NetCDF levels (in metres) to increase with increasing height, where the rate of change of pressure with respect to height is greatest. This is clearly shown in Figure 1 where the greatest distance between the NetCDF and MEDOC grids occurs at the highest point in the terrain. So any interpolation carried out will have

greater error at points of higher terrain, but note that the magnitude of the error is not expected to be large over most of Australia.

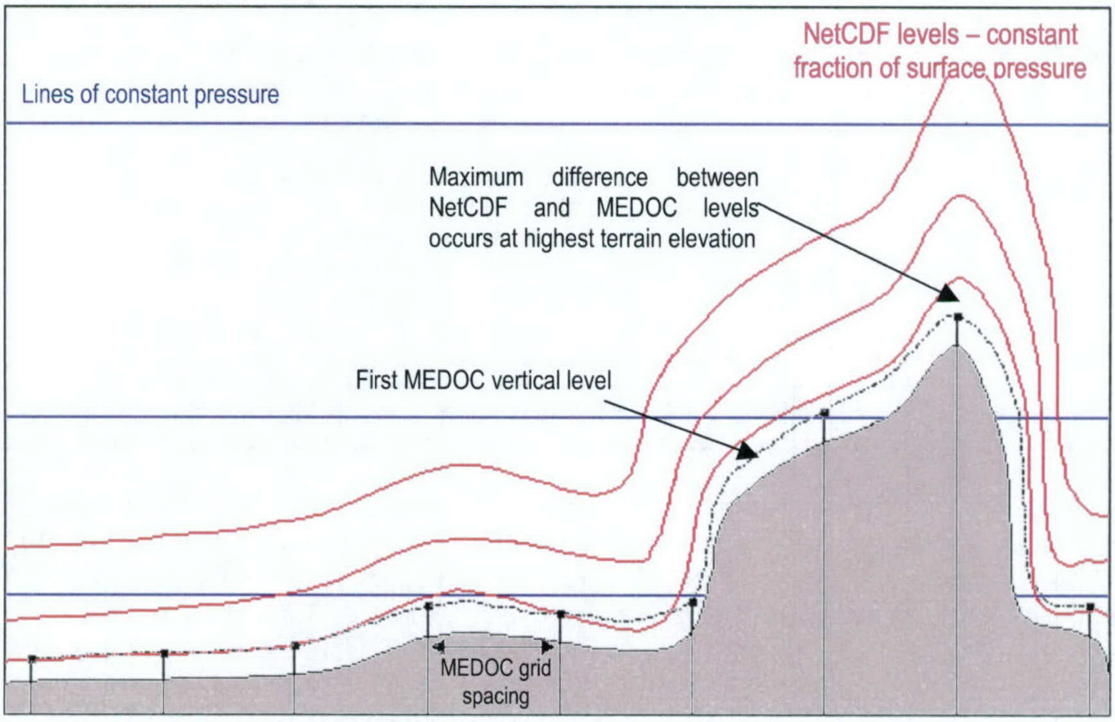

Figure 1: Including terrain in the interpolation problem

Using the ideas from Figure 1, a variable mapping table was drawn up linking NetCDF variables with corresponding MEDOC variables, as shown in Table 5 below. Note that the NetCDF and MEDOC variables are in italic and bold face respectively. The position of the grid is defined by the *lat* & *lon* NetCDF variables which define the southwest corner of the grid. Temporal information also transfers almost directly from NetCDF to MEDOC format.

Table 5: NetCDF to MEDOC variable mapping

NetCDF Variable	MEDOC Variables	Comments & Adjustments
lat (deg_N)	**LAT** - Single scalar of southern most point **DX** - Grid spacing in north-south direction (deg) **IMAX** - Number of grid points in x direction	The *lat* variable is written directly to its MEDOC counterpart **LAT**

lon (deg_E)	**LON** - Single scalar of western most point **DY** - Grid spacing in east-west direction (deg) **JMAX** - Number of grid points in y direction	The *lon* variable is written directly to its MEDOC counterpart **LON**
valid_date (yyyymmdd)	**IDAY** - dd (day) component of *valid_date* **IMONTH** - mm (month) component of *valid_date* **IYEAR** - yyyy (year) component of *valid_date*	The date is mapped directly
valid_time (hhmm UTC)	**IHOUR** - hh (hour) component of *valid_time* **IMIN** - mm (minute) component of *valid_time* **ISEC** - Set seconds to zero	The time is mapped directly, "seconds" data is not available in the NetCDF files
	KMAX - Fixed at 11 - 1 = 10 levels (Extra level needed for interpolation process)	Current BoM files are supplied with lowest 11 vertical levels (up to approx 1km above the surface)
geop_ht (m) *topog* (m)	Used to calculate **SZ** (m) – vertical height levels of grid (terrain transformed)	**SZ** is calculated using Equation (1)
lvl (sigma) *sfc_pres* (Pa)		Pressure at any point = *lvl* * *sfc_pres* (used during interpolation)
zonal_wind (m/s) *merid_wind* (m/s) *omega* (Pa/s)	**U** – corresponds to interpolated zonal (east-west) winds (m/s) **V** – corresponds to interpolated meridional (north-south) winds (m/s) **W** – corresponds to converted omega (vertical) winds (m/s)	Vertical winds must be interpolated and then converted to m/s
air_temp (K) *mix_rto* (g/g)	**TA** – Interpolated air temperature (K) **H** – Interpolated humidity ratio (g/g)	
abl_ht (m) *sfc_ttl_heat_flx* (W/m^2)	**ZI** – Atmospheric boundary layer height (m) **HFLX** – Total surface heat flux (W/m^2)	ZI and HFLX are 2D variables and require no interpolation

The geopotential height (height above mean sea level) is used along with the topography to determine heights above the surface. The MEDOC format requires a list of the vertical heights at the southwest corner of the grid and stores this information in the variable *SZ*. *SZ* is fixed for each level, but follows the terrain elevation according to the formula found in the User's Guide [1] and shown below,

$$SZ = H(z-h)/(H-h), \qquad (1)$$

where H is the extent of the vertical aspect of the modelling domain (taken to be the height of the NetCDF grid), z is the height of the position above sea level (geopotential

height in our application) and h is the terrain elevation (given by the topography variable in the NetCDF file). Figure 2 (below) shows a 3-D view of the situation over example topography with the all variables from Equation (1) marked.

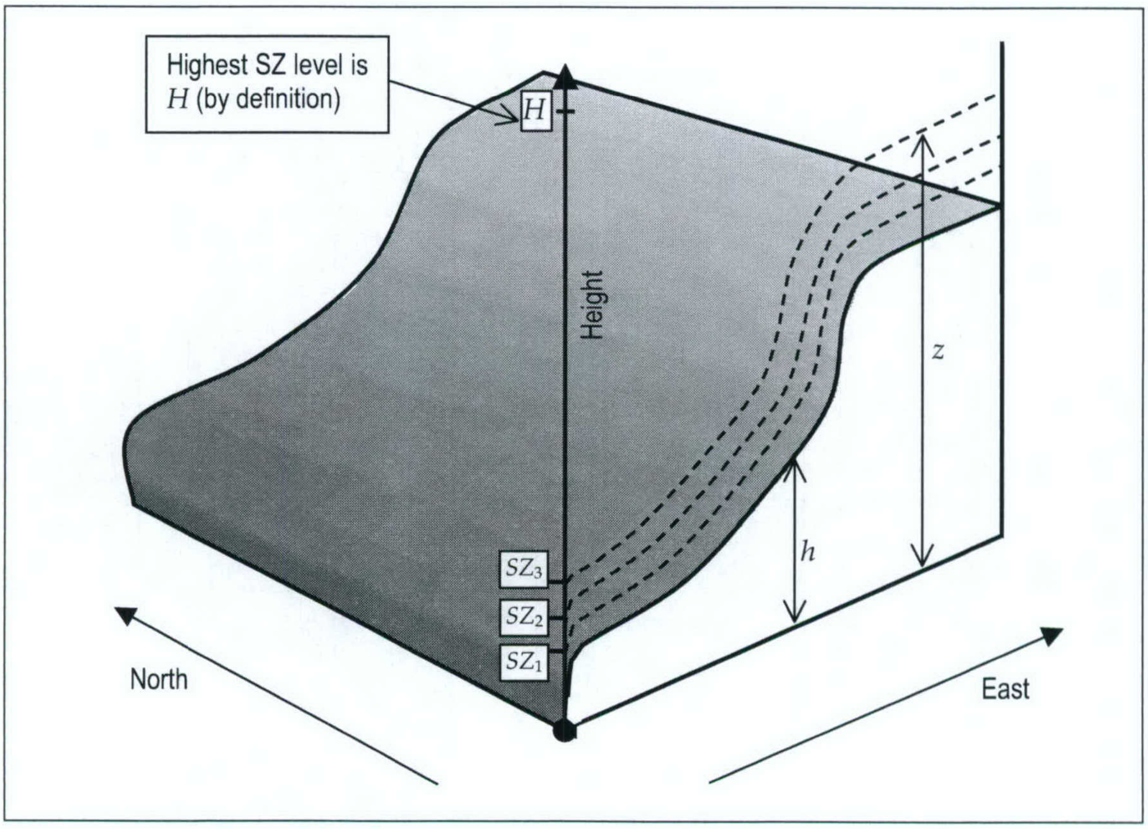

Figure 2: MEDOC terrain following grid levels over 3-D terrain

The interpolation of the 3D data (wind, temperature, humidity) is then completed using simple geometry and assuming that locally the variation in these variables is linear. This is illustrated in Figure 3 below, with the subscript k indicating the vertical position on the grid (k = 1, 2, ..., 11).

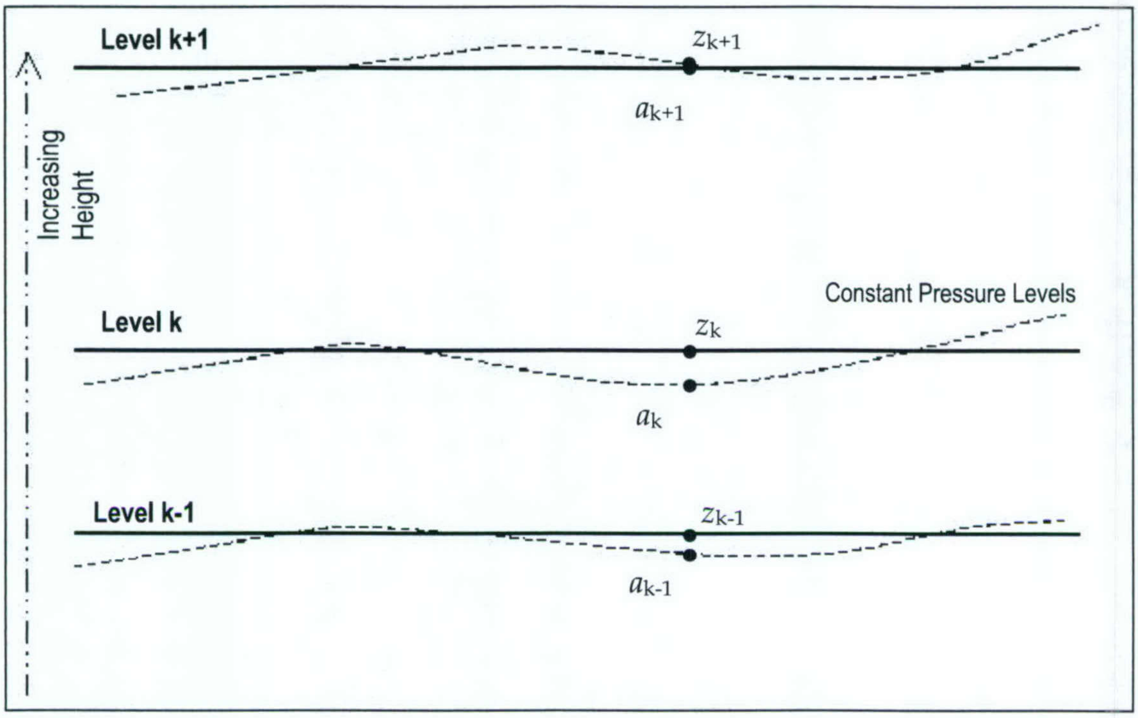

Figure 3: Linear interpolation descriptive diagram

Let:

- z_k be the geopotential height corresponding to vertical level k,
- a_k be the geopotential height of the original pressure level k and
- x( ) be a function that returns 3-D data (eg. wind) at a given position.

Assuming x( ) varies linearly with height implies the relation,

$$\frac{z_k - a_k}{a_{k+1} - a_k} = \frac{\mathrm{x}(z_k) - \mathrm{x}(a_k)}{\mathrm{x}(a_{k+1}) - \mathrm{x}(a_k)}$$

$$\Rightarrow \mathrm{x}(z_k) = \left(\mathrm{x}(a_{k+1}) - \mathrm{x}(a_k)\right)\left(\frac{z_k - a_k}{a_{k+1} - a_k}\right) + \mathrm{x}(a_k) \qquad (2)$$

Equation (2) will be used to do the interpolation of all 3-D data from NetCDF sigma levels to MEDOC terrain-following height levels.

The vertical winds presented a more difficult task as they are supplied by the BoM in units of pascal per second (Pa/s). Converting to metres per second (m/s) requires a factor with units of metres per pascal, as illustrated below,

$$W[\mathrm{m/s}] = \frac{\partial z}{\partial t}[\mathrm{m/s}] = \frac{\partial z}{\partial p}[\mathrm{m/Pa}]\,\frac{\partial p}{\partial t}[\mathrm{Pa/s}] = \frac{\partial z}{\partial p}[\mathrm{m/Pa}]\; W[\mathrm{Pa/s}],$$

where W, t and p represent the vertical wind velocity, time and pressure respectively, with units given in brackets. Hence an appropriate conversion factor can be calculated with units of pascal per metre by evaluating the rate of change of pressure p with respect to height z (metres) at each point on the grid. In the meteorology text by Stull [6], this rate of change is explicitly expressed in the form of the hydrostatic equation, as shown below,

$$\frac{\partial p}{\partial z} = -g\rho \,, \tag{3}$$

where g is the acceleration due to gravity and ρ is the density in kg/m^3. As we are dealing with only the first kilometre or so above the surface in this application, g can be assumed to be constant and equal to 9.8 m/s^2. To express ρ in terms of known quantities, we use Boyle's Law for a perfect gas, which states,

$$p = R\rho T \,, \tag{4}$$

where T represents the temperature (in units of Kelvin) and R is a constant with value of 2.8703 J /K kg when p is in units of millibar. Combining Equations (3) and (4) gives the relation,

$$\frac{\partial p}{\partial z} = -\frac{g}{RT}p \,. \tag{5}$$

Note that the pressure data are in units of pascals and not millibar in the supplied NetCDF files so Equation (5) in our case will be modified to,

$$\frac{\partial p}{\partial z} = -\frac{g}{100RT}p \,. \tag{6}$$

Hence the reciprocal of Equation (6) is in units of m/Pa and can be used to convert the vertical winds from Pa/s to m/s as required. More details on the variation of pressure with height can be found in most meteorology texts, such as that by Stull [6].

3.4 Reformatting Formulae

The interpolative formulae that the program will use can now be assembled, as shown in Table 6. Note that subscripts have been added to most variables to indicate their positions on the 3-D grid, where i indicates the east-west direction, j the north-south direction and k the vertical direction.

Table 6: NetCDF to MEDOC Iterative Interpolation Formulae

NETCDF TO MEDOC ITERATIVE FORMULAE				
Variable Definitions				
NetCDF Variables				
lvl	=	lvl_k	where	i = 1, 2, …, IMAX
geop_ht	=	g_{ijk}		j = 1, 2, …, JMAX
topog	=	top_{ij}		k = 1, 2, …, KMAX
sfc_pres	=	sp_{ij}		
zonal_wind	=	u_{ijk}		
merid_wind	=	v_{ijk}		
air_temp	=	t_{ijk}		
omega	=	o_{ijk}		
mix_rto	=	mr_{ijk}		
abl_ht	=	hg_{ij}		
sfc_ttl_heat_flx	=	hf_{ij}		
Program Variables				
P_{ijk}	=	Atmospheric pressure (Pa)		
TTH_{ijk}	=	Terrain transformed height (m)		
IO_{ijk}	=	Interpolated vertical wind (Pa/s)		
pf_{ijk}	=	Factor for converting vertical winds (m/Pa)		
MEDOC Variables				
SZ_k	=	Vertical levels (m)		
U_{ijk}	=	U winds (m/s)		
V_{ijk}	=	V winds (m/s)		
W_{ijk}	=	W winds (m/s)		
TA_{ijk}	=	Absolute temperature (K)		
H_{ijk}	=	Humidity ratio (g/g)		
$TOPO_{ij}$	=	Terrain elevation (m)		
$HFLX_{ij}$	=	Total surface heat flux (W/m^2)		
ZI_{ij}	=	Atmospheric boundary layer height (m)		

Iterative Formulae

Calculate height of each vertical grid level, using Equation (1)

for (k from 1 to KMAX) do

$SZ_k = g_{11KMAX} * (g_{11k} - top_{11}) / (g_{11KMAX} - top_{11})$

end for loop

Calculate Pressures and Terrain changes at each point

for (i from 1 to IMAX) do

for (j from 1 to JMAX) do

for (k from 1 to KMAX) do

Calculate Pressures from sigma levels and surface pressures

$P_{ijk} = lvl_k * sp_{ij}$

Calculate Terrain Transformed Heights (TTH) (essentially the geopotential at each point on the MEDOC grid) for each position (using geopotential at corner as a reference height)

$TTH_{ijk} = g_{11k} + top_{ij} - top_{11}$

end for loop

end for loop

end for loop

Start new loop to interpolate winds, temperature and humidity

for (i from 1 to IMAX) do

for (j from 1 to JMAX) do

for (k from 1 to KMAX) do

Interpolate zonal winds to constant height level using Equation (2)

$U_{ijk} = [u_{ijk+1} - u_{ijk}] \{ (TTH_{ijk} - g_{ijk}) / (g_{ijk+1} - g_{ijk}) \} + u_{ijk}$

Interpolate meridional winds to constant height level using Equation (2)

$V_{ijk} = [v_{ijk+1} - v_{ijk}] \{ (TTH_{ijk} - g_{ijk}) / (g_{ijk+1} - g_{ijk}) \} + v_{ijk}$

Interpolate air temperature to constant height level using Equation (2)

$TA_{ijk} = [t_{ijk+1} - t_{ijk}] \{ (TTH_{ijk} - g_{ijk}) / (g_{ijk+1} - g_{ijk}) \} + t_{ijk}$

Interpolate humidity ratio to constant height level using Equation (2)

$H_{ijk} = [mr_{ijk+1} - mr_{ijk}] \{ (TTH_{ijk} - g_{ijk}) / (g_{ijk+1} - g_{ijk}) \} + mr_{ijk}$

Interpolate omega (vertical winds) to constant height level using Equation (2)

$IO_{ijk} = [o_{ijk+1} - o_{ijk}] \{ (TTH_{ijk} - g_{ijk}) / (g_{ijk+1} - g_{ijk}) \} + o_{ijk}$

Convert omega from Pa/s to m/s by dividing by factor with units Pa/m (use Equation (6))

$pf_{ijk} = -0.034143 * P_{ijk} / TA_{ijk}$

$W_{ijk} = IO_{ijk} / pf_{ijk}$

```
# Map 2D variables to MEDOC equivalents #
            TOPO_ij = top_ij
            HFLX_ij = hf_ij
            ZI_ij = bh_ij
        end for loop
    end for loop
end for loop
```

Note that the interpolation process is linear in all variables and takes into account the changing topography.

4. AWSMSTR Program

AWSMSTR.EXE is a program which sits in the background on 32-bit Microsoft Windows Systems (Windows 95 or later). At specified intervals it runs a batch file called AWSLIST.BAT which then invokes an FTP (File Transfer Protocol) script called AWSLIST.SCP which uses the FTP program to download over the Internet a directory listing from a remote FTP server which is then saved in a file named AWS.LST. The program then constructs a directory listing file named LOC.LST for the directory in which it resides.

Just prior to running the batch file, AWSMSTR checks for the presence of a file AWSMSTR.FLG. If this file (which was created by AWSMSTR when it was first started) no longer exists then AWSMSTR will cease execution and remove itself from memory. The deletion of this 'flag' file is thus the method provided for closing the AWSMSTR program. Any messages or exception output created by AWSMSTR are placed in the file AWSERROR.LOG.

The program then searches the two directory listings for files which will be of interest because their names match templates specified in the file AWSFILE.TFN (see Appendix D for a description of this file), creates an internal list of files which are present on the FTP server but not in the local directory, and deletes any matching files which are present in the local directory but not present on the FTP server. It then uses the internal list of files in conjunction with the header file AWSGETSC.HDR to construct an FTP script called AWSGET.SCP. AWSMSTR then runs a batch file called AWSGET.BAT which uses the FTP script just constructed to connect to the FTP server and download the files of interest which are present on the FTP server but not in the local directory.

Having downloaded the required files, AWSMSTR then submits the downloaded files to a translator program, one at a time and then becomes idle until the next specified download interval.

The AWSMSTR program must be invoked using a command line of the form:

AWSMSTR <interval minutes> <keyword> <translator program> <output directory>
eg. AWSMSTR 30 melbourne .\BOM2HPAC.EXE .\OUTPUT

The translator program written for this exercise is called BOM2HPAC.EXE. When run, this program will translate the file specified as the first argument on its command line and place the output, suitably named, into the directory specified as the second argument on its command line. When called by AWSMSTR, BOM2HPAC will be supplied with the correct file name and the output directory which was specified on the command line for AWSMSTR.

BOM2HPAC will use correct algorithms to translate and rename several different types of input files using filename template data supplied in the file BOM2HPAC.TFN as specified in Appendix E.

5. Downloading Process

The downloading process is quite simple but takes a few moments to set up. The procedure for setting up the program is detailed in Appendix C. Once set up, there are two shortcuts on the desktop, one for downloading observational data and one for downloading the gridded forecast data (note that at this stage it has not been possible to have a single executable that downloads both observational and forecast data simultaneously as the data are not available in a single directory on the BoM ftp server). Each of these will run in the background, with a command window popping up to indicate that a connection to the BoM ftp server is being made and new files downloaded. There are three types of files that are output ready for use in HPAC, surface observations in METAR format (.sao extension), upper-air observations in RAOBS format (.wmo extension) and gridded MEDOC data (.fmt extension). Exiting the AWSMSTR program is a simple process of deleting the two awsmstr.flg files that are contained in the downloading directories.

When importing meteorological data the AWSMSTR program appends the date and time of the data to the filename (see Appendix D), with all times recorded in UTC (Universal Time Coordinated). This is especially important when deciding which files to import for an HPAC modelling run.

The MEDOC files are then ready to import into HPAC via the Weather Wizard's *Use Existing HPAC Files As Is* option. A single MEDOC file is output for each 36 hour

forecast, with sizes nearly 2.5 times larger than the total size of the forecast files downloaded. This increase in size is due to the less efficient (compared to NetCDF) way that the MEDOC format is structured. The largest MEDOC files that are produced are from the Sydney region and are nearly 42 MB in size. HPAC has little trouble coping with file sizes like this, with test-run times still very low.

6. References

[1] Science Applications International Corporation (2003), *The HPAC User's Guide Version 4.0.3*, HPAC-UGUIDE-01-RBC1, San Diego, CA, Appendix C.

[2] Whiteman, C D (2000), *Mountain Meteorology - Fundamentals and Applications*, Oxford University Press, NY, Chapter 9.3.3.

[3] Office of the Federal Coordinator for Meteorology (1997), *Federal Meteorological Handbook No. 3 - Rawinsonde and Pibal Observations*, FCM-H3-1997, URL - http://www.ofcm.gov/fmh3/text/appen-e.htm, Appendix E.

[4] University Corporation for Atmospheric Research (August 2004), *Unidata NetCDF*, URL - http://my.unidata.ucar.edu/content/software/netcdf/index.html.

[5] Sykes, R I, Parker, S F, Henn, D S, Cerasoli, C P and Santos, L P (2000), *PC-SCIPUFF Version 1.3 Technical Documentation*, ARAP Report No. 725, Titan Corporation, ARAP Group, Princeton, NJ, Section 13.

[6] Stull, R B (1999), *An Introduction to Boundary Layer Meteorology*, Kluwer Academic Publishers, Dordrecht, The Netherlands, Chapter 3.

[7] Damens, J, da Cruz, F and Catchings, B, (1985), *C-Kermit Version 4C*, Columbia University's Center for Computing Activities, URL - http://www.columbia.edu/kermit/msk30.

Appendix A: Surface Observation Examples

A.1. [metar2Data].axf type example

```
[metar2Data]
ID_num, ID_name[6], Date, Time, Lat, Lon, Wdir, Wspd, T_DB, DP, QNH,
RF9am, RF10m, Vis, AVis, Gust, Wx1Int, Wx1Dsc, Wx1Wx1, Wx1Wx2, Wx1Wx3,
Wx2Int, Wx2Dsc, Wx2Wx1, Wx2Wx2, Wx2Wx3, Cld1Amt, Cld1Typ, Cld1Base,
Cld2Amt, Cld2Typ, Cld2Base, Cld3Amt, Cld3Typ, Cld3Base, Cld4Amt,
Cld4Typ, Cld4Base, Ceil1Amt, Ceil1Base, Ceil2Amt, Ceil2Base, Ceil3Amt,
Ceil3Base
95204, "WSR  ", 20031116, 0600, -17.90, 122.31, 260, 13.0,  32.5, -
9999.0, -9999.0,   0.0,   0.0, -9999, -9999, 20.0, -9999, -9999, -
9999, -9999, -9999, -9999, -9999, -9999, -9999, -9999, -9999, -9999, -
9999, -9999, -9999, -9999, -9999, -9999, -9999, -9999, -9999, -9999, -
9999, -9999, -9999, -9999, -9999, -9999
94430, "YMEK ", 20031116, 0546, -26.61, 118.54, 030, 17.0,  30.1,
11.3, 1004.6,   0.0,   0.0, 10000, 10000, 29.0, -9999, -9999, -9999, -
9999, -9999, -9999, -9999, -9999, -9999, -9999,  1,  7,   600,  3,  8,
2400,  3,  9,  2100, -9999, -9999, -9999, 11,  2490, -9999, -9999, -
9999, -9999
94317, "YNWN ", 20031116, 0539, -23.42, 119.80, 350, 16.0,  34.2,
10.1, 1007.8,   0.0,   0.0, -9999, -9999, 26.0, -9999, -9999, -9999, -
9999, -9999, -9999, -9999, -9999, -9999, -9999, -9999, -9999, -9999, -
9999, -9999, -9999, -9999, -9999, -9999, -9999, -9999, -9999, -9999, -
9999, -9999, -9999, -9999, -9999
```

A.2. HPAC's METAR format for surface observations example

```
METAR YHLC 161230Z 15009KT //// 24/20 Q1012
METAR YPKU 161230Z 01008KT //// 29/21 Q1010
METAR YARG 161230Z 34007KT //// 32/19 Q1011
METAR YBRM 161230Z 28011KT //// 28/22 Q1011
METAR YPPD 161230Z 28012KT //// 25/15 Q1011
METAR YPKA 161230Z 29014KT //// 25/16 Q1011
METAR YPLM 161230Z 28009KT //// 23/16 Q1011
METAR YCAR 161230Z 32009KT //// 22/17 Q1009
METAR YMEK 161230Z 22006KT //// 22/12 Q1009
METAR YGEL 161230Z 31004KT //// 19/17 Q1009
METAR YPPH 161230Z 21010KT //// 20/15 Q1007
METAR DOPY 161230Z 18014KT //// ///// Q////
METAR YPJT 161230Z 22012KT //// 19/15 Q1007
METAR YRTI 161230Z 19020KT //// 18/15 Q1006
METAR OCEA 161230Z 20017KT //// ///// Q////
METAR SWAN 161230Z 20013KT //// 19/16 Q////
METAR PERT 161230Z 21009KT //// 20/15 Q1007
METAR YESP 161230Z 06005KT //// 17/13 Q1011
METAR YABA 161230Z 07009KT //// 15/14 Q1007
METAR YEST 161230Z 07005KT //// 17/14 Q1011
METAR ECLT 161230Z 12007KT //// 16/14 Q1011
```

Appendix B: Gridded Forecast Data – MEDOC Example

```
FFFFFFFF
TRNSGRIB
          11          11        2003          12           0           0
          11          11        2003          12           0           0
          11          19          10           0           5           3
           0           0           0           0           0           0
           0           0           0
     10.1713     21.9336     48.0274    105.5031    212.0182    319.6505
    428.3995    649.4742    875.9681   1108.6001      0.1250      0.1250
-999999.0000 -999999.0000   -43.2500    146.7500      0.0000      0.0000
      0.0000      0.0000      0.0000
U         V         W         TA        H
M/S       M/S       M/S       KELVIN    GM/GM
TOPO      METERS    HFLX      W/m**2    ZI        M
     14.1074     11.7645      9.4437      8.8821      9.4905     10.1203
     10.7202     11.3682     11.9817     12.5280     13.2309      9.2971
      9.4522      9.3462      9.2524      8.4669      8.1637      8.1594
      9.4280     11.4099     12.5430     12.5580      8.3281      8.1465
      8.6042      9.8755      8.9849      7.1762      5.7191      7.1310
      9.6505     11.3072     11.4873      8.5472      7.9655      8.4571
      9.2701      8.4498      7.0408      4.8109      5.9415      8.3236
      9.9089     10.3761      6.9883      6.7481      6.9886      7.0376
      6.9724      7.1990      6.6003      7.2729      8.5935      9.3220
      9.8514      6.0430      5.9069      6.0163      6.0677      6.2970
      6.8710      7.6036      8.4942      8.8278      8.4706      9.1721
      5.5502      5.5143      5.6348      5.8513      6.0079      6.6891
      7.4764      8.2701      8.9252      7.8046      8.1529      5.4278
      5.3123      5.6584      6.4639      6.4542      6.0617      6.3068
      7.0031      7.7835      7.5213      6.9956      5.7464      5.4900
      6.6537      8.6462      6.9971      4.6859      4.2701      5.4281
      7.0133      6.9584      6.0480      6.3856      6.6591      8.1983
      9.3517      6.6847      3.7711      3.4776      5.1668      7.7495
    .   .          .           .           .           .
    .   .          .           .           .           .
    .   .          .           .           .           .
FFFFFFFF
TRNSGRIB
          11          11        2003          15           0           0
          11          11        2003          15           0           0
          11          19          10           0           5           3
           0           0           0           0           0           0
           0           0           0
     10.1266     21.8309     47.7782    104.8865    210.6732    317.5629
    425.5577    644.8875    869.2156   1099.5909      0.1250      0.1250
-999999.0000 -999999.0000   -43.2500    146.7500      0.0000      0.0000
      0.0000      0.0000      0.0000
U         V         W         TA        H
M/S       M/S       M/S       KELVIN    GM/GM
TOPO      METERS    HFLX      W/m**2    ZI        M
      2.0468      1.3312      2.3943      3.4582      3.2527      5.6552
      7.3278      8.8878      9.8600     11.1821      8.5576      2.8381
    .   .          .           .           .           .
    .   .          .           .           .           .
```

Appendix C: AWSMSTR.exe Set-up Procedure

Step 1 – Create observational and NWP directories in HPAC `\rawmet` directory.
Step 2 – Unzip `obs.zip` into observation folder, `nwp.zip` into NWP folder
Step 3 – Create shortcut for downloading observational data
Step 4 – Create shortcut for downloading forecast data, and edit to include the gridded area of interest.
Step 5 – Adjusting `AWSMSTR.exe` for non-Defence use
Step 6 – Additional notes and technical support

Step 1 – Create Directories

- HPAC will by default look in a directory called `\rawmet` when importing both observational and forecast weather data. It makes sense then to set up the downloading programs from this directory.
- Find the `\rawmet` directory, usually at `C:\HPAC4\client\shared\rawmet`
- Add two new directories, `\obsdwnld` and `\nwpdwnld`
- The observational weather data will be saved in `\obsdwnld`, and the forecast data will be put in `\nwpdwnld`

Step 2 – Unzip Program Files

- Using WinZip or another similar extraction program, extract the contents of `obs.zip` into `C:\HPAC4\client\shared\rawmet\obsdwnld`
- Extract `nwp.zip` into `C:\HPAC4\client\shared\rawmet\nwpdwnld`

Step 3 – Create Observations Downloading Shortcut

- In `\obsdwnld`, find the program `AWSMSTR.exe`
- Right-click and select *Create Shortcut*
- Drag this shortcut to the desktop
- Right-click on desktop icon and select *Properties*
- Click on the *Shortcut* tab
- Locate the *Target:* editable field.
- This field contains 5 pieces of important information for the downloading process:
    - The name and location of `AWSMSTR.exe`
    - The time interval (in minutes) between looking for updated files on the BoM ftp server
    - The city/cities for which to download the large forecast files
    - The location and name of the translator program
    - The destination of converted files
- An example is shown below which downloads all observations every 30 minutes, gets forecast data from Melbourne (`AWSMSTR` requires the keyword, but note that this incarnation of `AWSMSTR` will download observations only), and puts files in the current directory.

- `C:\HPAC4\client\shared\rawmet\obsdwnld\AWSMSTR.exe 30 melbourne C:\HPAC4\client\shared\rawmet\obsdwnld\BOM2HPAC.exe C:\HPAC4\client\shared\rawmet\obsdwnld`
- Rename the desktop shortcut "Observations Download" or something similar
- When run the program downloads and reformats all surface and upper-air observational data from around Australia and saves files in the `\obsdwnld` directory

❑ Step 4 – Create Forecast Downloading Shortcut

- The procedure is virtually identical for the forecast data download
- In `\nwpdwnld`, find the program `AWSMSTR.exe`
- Right-click on select *Create Shortcut*
- Drag this shortcut to the desktop
- Right-click on the desktop icon and select *Properties*
- Click on the *Shortcut* tab
- Locate the *Target:* editable field
- This field contains 5 pieces of important information for the downloading process:
  - The name and location of `AWSMSTR.exe`
  - The time interval (in minutes) between looking for updated files on the BoM ftp server
  - The city/cities for which to download the large forecast files
  - The location and name of the translator program
  - The destination of the converted files
- An example is shown below which downloads all forecast data from Melbourne (checking for new data every 120 minutes), and saves the files in the current directory
- `C:\HPAC4\client\shared\rawmet\nwpdwnld\AWSMSTR.exe 120 melbourne C:\HPAC4\client\shared\rawmet\nwpdwnld\BOM2HPAC.exe C:\HPAC4\client\shared\rawmet\nwpdwnld`
- Rename the desktop shortcut "Forecast Download" or something similar
- When run, the program downloads and reformats all forecast data for the specified city/cities and saves files in the `\nwpdwnld` directory. Note that the forecast data is only updated every 12 hours, at approx 0300 and 1500 UTC (1pm and 1am AEST)

❑ Step 5 – Adjust For Non-Defence Use

- `AWSMSTR` was designed primarily for use within Defence networks but can be easily adjusted for use on any network by adjusting the contents of `awsget.bat`, `awslist.scp` and `awsgetsc.hdr` to reflect the ftp proxy appropriate to the end-user. The `AWSMSTR` software is available to licensed HPAC users upon request to the authors.

- Step 6 – Additional Notes
  - Also required for use of observational data is the updated version of the weather station file, `wmo.stn`. Run a search on the HPAC directory and locate all instances of `wmo.stn` (there should be two). Rename each file `wmo_old.stn` and copy the new DSTO supplied `wmo.stn` into these directories.
  - Due to the non-uniqueness inherent in METAR files (only the time and day of the month is recorded), it is suggested that no more than one month of downloaded observations is kept in the `\rawmet` directory, as HPAC may fail to import observations or incorrectly assign observations to the current HPAC project's month. Given the short-term nature of most dispersion scenarios this will rarely be an issue.
  - Note that at this stage the BoM are unable to provide all data in a single directory on their ftp server, hence the need for two programs, one downloading observational data, the other the NWP forecast data. It is hoped that in the future the BoM can provide all data in a single directory so that only one program will be required to download all BoM data.
  - Possible keywords to specify the area of interest for NWP data are:
    - Melbourne and surrounds `melbourne`
    - Sydney and surrounds `sydney`
    - Canberra region `canberra`
    - Adelaide and surrounds `adelaide`
    - Brisbane and Gold Coast `brisbane`
    - Darwin region `darwin`
    - Perth and surrounds `perth`
    - Hobart and Launceston `tasmania`
  - To download forecasts from more than one region, simply separate as many of the keywords as required with commas. For example to download both Melbourne and Sydney data, use the keywords `melbourne,sydney` in the command line.
  - Note that a keyword (or more than one) must be included in the command line. For the observations-only program run, inclusion of a keyword is mandatory but does not affect the files downloaded, which still contain all observational data from around Australia.
  - To stop the programs from running, locate the two `awsmstr.flg` files (one in each of the `\obsdwnld` and `\nwpdwnld` directories) and delete.

If you have any problems, contact Alex Hill at DSTO via email (alexander.hill@dsto.defence.gov.au), telephone 03) 9626 8272 or mobile 0439 463 252

Appendix D: AWSFILE.TFN Templates

The file-name templates specified in this file are lines having the form of a 'keyword' followed by an equals (=) character, followed by a list of templates which are enclosed in double-quotes and separated by commas.

keyword="template", "template", "template",....

Templates corresponding to the keyword 'global' will always be used in addition to the templates corresponding to one other keyword which is specified on the `AWSMSTR` command line. A filename need match only one of the specified templates in order to be accepted as a match. The current `AWSFILE.TFN` file is shown in Figure D1.

```
global="*.txt","*.axf"
melbourne="IDY04287_>4Y>M>D>h_>3d.nc"
sydney="IDY04288_>4Y>M>D>h_>3d.nc"
canberra="IDY04289_>4Y>M>D>h_>3d.nc"
adelaide="IDY04290_>4Y>M>D>h_>3d.nc"
brisbane="IDY04291_>4Y>M>D>h_>3d.nc"
darwin="IDY04292_>4Y>M>D>h_>3d.nc"
perth="IDY04293_>4Y>M>D>h_>3d.nc"
tasmania="IDY04299_>4Y>M>D>h_>3d.nc"
```

Figure D1: Current AWSFILE.TFN

Wildcards accepted in the file name templates are:
'*' for zero or more arbitrary characters;
'?' for any one character.

Unlike the MS-DOS wildcard match, '*' is correctly handled even if it isn't at the end of the template. Note that the period '.' is not a special character. The wildcard handling code was originally written by Jeff Damens of Columbia University's Center for Computing Activities and is taken from the source code for C-Kermit version 4C [7].

File name templates can also include text-substitution macros as specified below. The first character of all macros is a character which is not permitted in filenames and is not a wildcard - viz: the ">" character. The next character may be a decimal digit which specifies the size of a character string which comprises the macro or, if absent (with the exception of the d macro), the macro is only two characters long and the matching string only two characters long.

>4Y A 4-digit year eg. 2003

>2Y or
>Y A 2-digit year specifying the number of years since the last century

eg.03 == 2003 or 1903 or ...

>2M or
>M A 2-digit month of the year (1 - 12) eg. 07 == July

>2D or
>D A 2-digit day of the month (1 - 31) eg. 09

>2h or
>h A 2-digit hour of the day (0 - 23) eg 06

>2m or
>m A 2 - digit minute of the hour (0 - 59) eg. 05

>2s or
>s A 2 - digit second of the minute (0 - 59) eg. 02

>1d or >2d or >3d or >4d or ... a decimal integer having the specified number of digits OR
>d A decimal integer having an unspecified number of digits - the string to be matched is parsed until the end or until the first non-digit is encountered.

Appendix E: BOM2HPAC.TFN Templates

The file name templates specified in this file have the form:

keyword=[Input Filename Template List],[Output Filename Template List],

where any template list has each template enclosed in double-quotes and separated by commas as in Appendix D. The `BOM2HPAC` program searches each of the input template lists until it finds a match for the file specified on the command line. It then uses the keyword located on the same line to determine which translation algorithm to use. Time, date and numeric information extracted from the construction of the input filename macros are used in conjunction with the output filename template list located on the same line as the keyword to determine how to name the output file.
The current `BOM2HPAC.TFN` file is shown in Figure E1.

```
UPPER_AIR_OBS=["IDY07033*.txt"],["IDY07033*.wmo"]
SURFACE_OBS=["IDY03100*.axf"],["IDY03100*.sao"]
PRED_36HR=["IDY042??_>4Y>M>D>h_>d.nc"],["????????_>4Y>M>D>h.fmt"]
```

Figure E1: Current BOM2HPAC.TFN File Name Templates File

Wildcards and macros which may be included in this file are as specified in Appendix D.

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Alexander Hill, Peter Sanders & Ralph Gailis

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19. ABSTRACT

The Hazard Prediction and Assessment Capability (HPAC) is a hazard modelling tool that predicts the effects of the release of toxic materials to the atmosphere. Detailed meteorological data is required to obtain reliable modelling results, including surface observations, upper-air profiles and gridded forecast data. HPAC is a US developed model and cannot interpret locally available meteorological data. This report describes the DSTO-built computer program AWSMSTR which retrieves the relevant data from a remote server and reformats it for use in HPAC.

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